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ORIGINAL ARTICLE

Validation of the Extubation Predictive Score (ExPreS) and Visual pursuit, Swallowing attempt, Age, and Glasgow Coma Scale (VISAGE) score as predictors of extubation success in neurocritical patients

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Background: Extubation failure in neurocritical patients is strongly associated with poor outcomes; thus as physicians, identifying the neurocritical conditions prior to extubation is important. This increases the need for instruments that can accurately identify patients who are likely to undergo successful extubation. The objective of this study was to determine the predictive value of Extubation Predictive Score (ExPreS) and Visual pursuit, Swallowing attempt, Age, Glasgow Coma Scale (VISAGE) scores for successful extubation in neurocritical patients.

Methods: This was a prospective observational cohort study of neurocritical patients admitted to the intensive care unit of Adam Malik Hospital between July and December 2024. The ExPreS and VISAGE scores were used to assess predictive scores for extubation success. Extubation success was defined as no reintubation or use of mechanical ventilation within 48 hours after a spontaneous breathing test.

Results: There were 56 patients with most subjects being male, aged >40 years with a mean age of 48.9±16.5 years, with a diagnosis of head injury. Both predictive scores of extubation success in this study can be used to predict successful extubation in neurocritical patients (P<0.001), with an area under the curve (AUC) >0.8. The sensitivity value of ExPreS was 89.5%, specificity was 88.9%, and an AUC was 0.945, whereas the sensitivity value of VISAGE score was 63.2%, specificity was 94.4%, and the AUC was 0.876.

Conclusion: Owing to their high sensitivity, specificity, and diagnostic accuracy, ExPreS and VISAGE scores can be used as reliable parameters in order to determine extubation success in neurocritical patients on mechanical ventilation.

Keywords: Airway extubation; Validation study; Neurocritical care

INTRODUCTION

Neurological dysfunction is a prevalent cause for the initiation of mechanical ventilation and may arise from various factors, including metabolic failure, intoxication, hemorrhagic or ischemic stroke, and cerebral trauma. Among these, structural brain abnormalities (hemorrhage, stroke, and trauma) typically indicate the most unfavorable prognosis and pose significant challenges to clinicians [1,2]. While it has been suggested that the prognosis of critically ill neurological patients is predominantly determined by the underlying neurological illness, the impact of extracerebral organ dysfunction and ventilatory management on the outcomes in this group of patients is not well established [2-4].

Unfortunately, prolonged use of mechanical ventilators has ad-

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verse effects on lung function. Furthermore, from an economic perspective, prolonged intubation increases the cost of hospital care [5]. The decision to extubate critically ill neurological patients is challenging because extubation failure and delayed extubation are common in these patients. Delayed extubation leads to ventilator-associated pneumonia (VAP) and worsens brain injury due to hypoxemia, thus exacerbating the vicious cycle of VAP-prolonged intubation-head injury-low immunity-VAP [6]. Therefore, early extubation is the main goal of neurocritical care in order to achieve good patient outcomes. To date, there is no consensus on the best indicators and timing of extubation in regard to patients with head injuries and other neurological disorders [7]. Patients who have passed the spontaneous breathing test (SBT) are a common predictor, but are not applicable to neurocritical patients in whom airway and neurological functions can both be compromised [8].

Currently, two types of parameters have been studied to assess extubation success: the Extubation Predictive Score (ExPreS) and the Visual pursuit, Swallowing attempt, Age, Glasgow Coma Scale (VISAGE) score. The ExPreS, a multiparameter score that incorporates various parameters related to extubation outcomes, is a reliable predictor of extubation outcomes in patients receiving mechanical ventilation in the intensive care unit (ICU). Meanwhile, the VISAGE score can also facilitate patient assessment and showed great potential as a predictor of extubation outcome in severe brain injury [8]. However, there has been no validation test for these scores in a specific population of neurocritical patients, especially those using invasive mechanical ventilators. Therefore, we intended to compare the predictive abilities of the ExPreS and VISAGE scores as predictors of extubation success in neurocritical patients using mechanical ventilation who were treated in the ICU of Adam Malik General Hospital.

METHODS

Study design and setting

This study complied with the principles of the Declaration of Helsinki. The study protocol was reviewed and approved by the Health Research Ethics Commission of the Faculty of Medicine. This prospective observational cohort study was conducted from July to December 2024, using primary data from direct examination of neurocritical patients, the samples of this study were taken using consecutive sampling method. The inclusion criteria of this study were all of the neurocritical patients who used mechanical ventilators in the ICU room. Meanwhile, the exclusion criteria were patients who died/were referred before weaning or had self-extubation performed.

Sample size

The sample size was calculated based on the formula for prognostic research.

$$n = \frac{(Z\alpha)^2 \, Sen \, (1\text{-}Sen)}{d^2 P}$$

When considering sensitivity from previous research (Sen) of 62%, Zα of 1.96, precision (d) of 20 %, and the prevalence of case (P) of 40.1 %, the sample size was 56.

Data collection

All neurocritical patients admitted to the ICU were assessed daily according to inclusion and exclusion criteria. After being matched as a representative sample, written informed consent was obtained from legally authorized representatives. Fig. 1 depicts the flowchart of patient recruitment in this study. Spontaneous breathing trial was initiated if the patient was awake with a good cough reflex, a fraction of inspired oxygen (FiO_2) < 0.5; positive end-expiratory pressure (PEEP) < 5 cm H_2O; minute ventilation (MV) < 10 L/min; PaO_2/FiO_2 ratio ≥ 150 mm Hg; and afebrile with temperature < 38.5 °C at the time of assessment. The mode and settings of the ventilator used during SBT were adjusted according to the condition of the patient, such as pressure support ventilation, T-piece, or continuous positive airway pressure. The settings for PEEP, pressure support level, and FiO_2 were standardized across patients. A patient passed the trial if he or she avoided developing any of the following failure criteria within 120 minutes: (1) Respiratory rate of less than 8 bpm or more than 35 bpm for 5

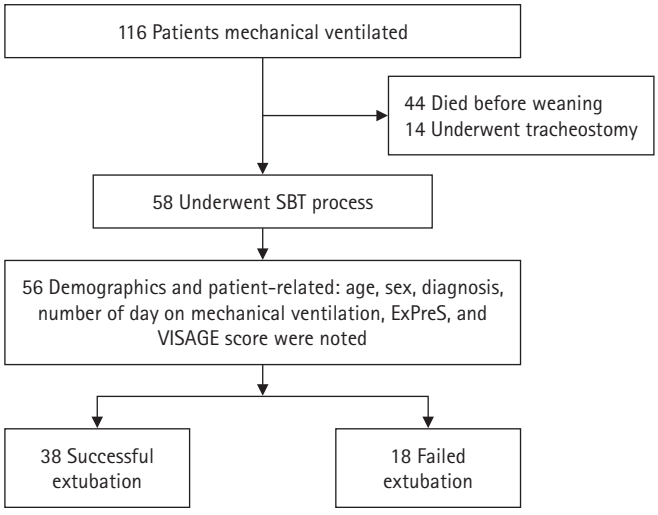
116 Patients mechanical ventilated
44 Died before weaning
14 Underwent tracheostomy
58 Underwent SBT process
56 Demographics and patient-related: age, sex, diagnosis, number of day on mechanical ventilation, ExPreS, and VISAGE score were noted
38 Successful extubation
18 Failed extubation

Fig. 1. Flowchart of the selection participants. SBT, spontaneous breathing test; ExPreS, Extubation Predictive Score; VISAGE, Visual pursuit, Swallowing attempt, Age, Glasgow Coma Scale.

minutes or longer. (2) Hypoxemia (SpO_2 < 88% for ≥ 5 minutes). (3) Abrupt change in mental status. (4) Acute cardiac arrhythmia. (5) Two or more signs of respiratory distress: tachycardia, bradycardia, use of accessory muscles, abdominal paradox, diaphoresis, and marked dyspnea.

A spontaneous breathing trial was performed for 120 minutes, and the following parameters were collected at the end of the test: (1) Demographics and patient-related factors: age, sex, diagnosis, length of ICU stay, ICU mortality, Acute Physiology and Chronic Health Evaluation (APACHE) II score, and Glasgow Coma Scale. (2) ExPreS and VISAGE scores were assessed. The respiratory and hemodynamic parameters of all samples were continuously monitored for 48 hours after extubation. The endpoint of the study was the extubation outcome in terms of extubation success or failure. Extubation success was defined as the non-requirement of reintubation or any form of MV support within 48 hours of extubation.

Statistical analysis

Univariate analysis was used in order to determine the characteristics of the participants. Receiver operating characteristic curves were used to compare the accuracy of the ExPreS and VISAGE scores in predicting successful extubation in neurocritical patients. If the area under the curve (AUC) value of each score was significant ($P < 0.05$), it was considered a significant predictor of extubation success. Significant AUC values were further analyzed to obtain the cutoff values of the ExPreS and VISAGE scores, followed by the sensitivity, specificity, and predictive values.

RESULTS

From a total of 116 mechanically ventilated patients during the study period, 56 patients were included in this study (Fig. 1), consisting of 13 traumatic brain injuries (23.2%), 12 hemorrhagic strokes (21.4%), 8 ischemic strokes (14.3%), 8 brain tumors (21.4%), and 6 central nervous system infections (10.7%). The overall characteristics of the participants are presented in Table 1. From the data recorded, there were found to be 18 extubation failures (32.1%), and extubation success was associated with lower in-ICU mortality, shorter duration of MV, and shorter ICU length of stay (Table 2).

The ExPreS score showed a high AUC value (0.945) with a cutoff score was ≥ 59, sensitivity of 89.5%, specificity of 88.9%, positive predictive value (PPV) of 94.4%, negative predictive value (NPV) of 80.0%, and diagnostic accuracy of 89.3% $P < 0.001$ (Fig. 2). In patients with ExPreS score ≥ 59, 94.4% of patients had extubation success, whereas in those with an ExPreS score < 59, only 20% had extubation success ($P < 0.001$, chi-square test) (Table 3). The patients with a higher ExPreS score ≥ 59 increased the success of extubation by 4.717 times as compared with those with an ExPreS score < 59, $P < 0.001$, relative risk (RR) 4.717; 95% CI 1.957–11.364.

The AUC of the VISAGE score was 0.876 with a cutoff VISAGE score ≥ 3, sensitivity of 63.2%, specificity of 94.4%, PPV of 96.0%, NPV of 54.8%, diagnostic accuracy of 73.2%, $P < 0.001$ (Fig. 3). In patients with VISAGE score ≥ 3, 96.0% of patients had extubation success, whereas in those with a VISAGE score

Table 1. Characteristics of the subjects

Variable	Overall population (n=56)	Patient with extubation success (n=38, 67.9%)	Patient with extubation failure (n=18, 32.1%)	*P*-value*
Age (yr)	48.9±16.5	47.6±16.3	51.6±16.8	0.401[a]
Male	32 (57.1)	25 (65.8)	7 (38.9)	0.057[b]
Diagnosis				0.304[c]
Traumatic brain injury	13 (23.2)	7 (18.4)	6 (33.3)	
Spinal cord injury	2 (3.6)	2 (5.3)	0	
Ischemic stroke	8 (14.3)	4 (10.5)	4 (22.2)	
Hemorrhage stroke	12 (21.4)	10 (26.3)	2 (11.1)	
Brain tumor	12 (21.4)	9 (23.7)	3 (16.7)	
CNS infection	6 (10.7)	5 (13.2)	1 (5.6)	
Status epilepticus	3 (5.4)	1 (2.6)	2 (11.1)	
APACHE II score on admission	11 (1–23)	10 (1–23)	12 (4–20)	0.176[d]
GCS admission	12 (6–15)	12 (6–15)	12 (6–15)	0.516[d]
ExPreS score	64.2±13.6	70.7±10.4	50.3±8.0	<0.001[a]

Values are presented as mean±standard deviation, number (%), or median (range).
CNS, central nervous system; APACHE, Acute Physiology and Chronic Health Evaluation; GCS, Glasgow Coma Scale; ExPreS, Extubation Predictive Score.
Analyzed using [a]Paired t-test; [b]Chi-square test; [c]Fisher's Exact test; and [d]Mann-Whitney test.
*Statistically significant at $P<0.05$.

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Table 2. Consequences of extubation success on ICU outcome

	Patient with extubation success (n=38, 67.9%)	Patient with extubation failure (n=18, 32.1%)	*P*-value*
Duration of mechanical ventilation	2 (2–8)	4 (2–10)	0.030[a]
ICU length of stay	6 (2–30)	12 (8–27)	0.008[a]
In-ICU mortality	3 (7.9)	9 (50.0)	0.001[b]

Values are presented as median (range) or number (%).
ICU, intensive care unit.
Analyzed using [a]Mann-Whitney test and [b]Chi-square test.
*Statistically significant at $P<0.05$.

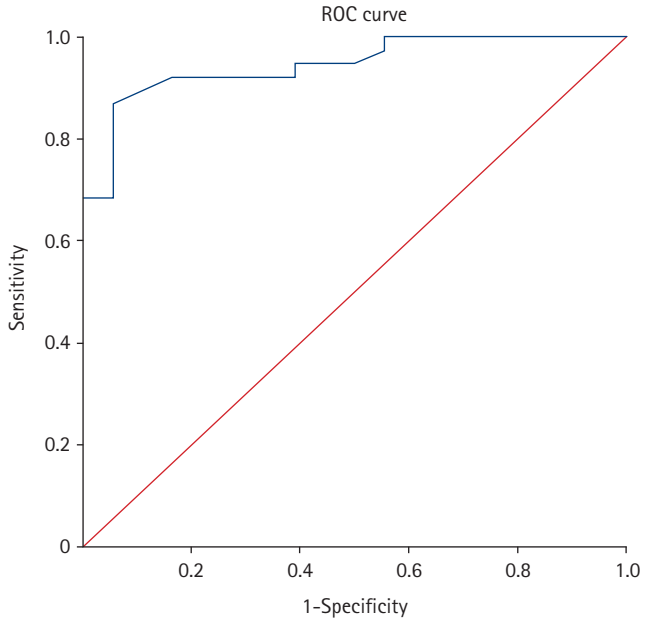

Fig. 2. The receiver operating characteristic (ROC) curve of the Extubation Predictive Score (ExPreS) score to predict extubation success, area under the curve of 0.945, cutoff ExPreS score ≥59, sensitivity 89.5%, specificity 88.9%, positive predictive value 94.4%, negative predictive value 80.0%, and diagnostic accuracy 89.3%.

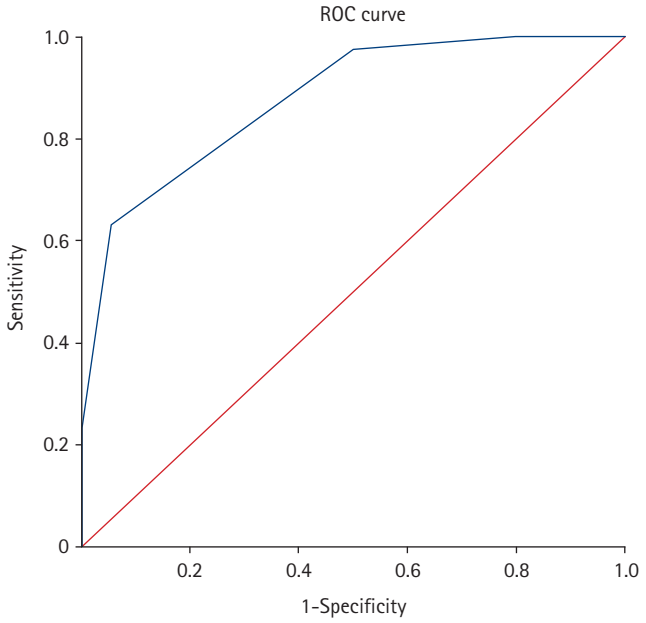

Fig. 3. The receiver operating characteristic (ROC) curve of the Visual pursuit, Swallowing attempt, Age, Glasgow Coma Scale (VISAGE) score to predict extubation success, area under the curve of 0.876, cutoff VISAGE score ≥3, sensitivity 63.2%, specificity 94.4%, positive predictive value 96.0%, negative predictive value 54.8%, and diagnostic accuracy 73.2%.

Table 3. Comparison of high and low ExPreS on extubation success

Variable	Extubation success	Extubation failure	Total	*P*-value*
ExPreS score high (≥59)	34 (94.4)	2 (5.6)	36 (100)	<0.001[a]
ExPreS score low (<59)	4 (20.0)	16 (80.0)	20 (100)	

Values are presented as number (%).
ExPreS, Extubation Predictive Score.
[a]Analyzed using chi-square test.
*Statistically significant at $P<0.05$.

<3, only 45.2% had extubation success ($P<0.001$, chi-square test) (Table 4). The patients with a higher VISAGE score ≥3 increased the rate of successful extubation by 2.12 times as compared to those with an ExPreS score <59 ($P<0.001$, RR 2.12; 95% CI, 1.431–3.154). To evaluate the clinical significance of each factor taken separately and in combination, we analyzed the rate of extubation success according to the number of factors and total score (Fig. 4). The rate of extubation success was 16.7% with a score of 1, and was higher in patients with a score of 2 or 3 (61.9%–94.1%).

DISCUSSION

Neurocritical patients are subject to complicating factors during hospital care due to mechanical factors and low immunity [9-12]. Secretion handling is one of the greatest challenges in maintaining

Table 4. Comparison of high and low VISAGE scores on extubation success

Variable	Extubation success	Extubation failure	Total	*P*-value*
VISAGE score high ≥3	24 (96.0)	1 (4.0)	25 (100)	<0.001[a]
VISAGE score low <3	14 (45.2)	17 (54.8)	31 (100)	

Values are presented as number (%).
VISAGE, Visual pursuit, Swallowing attempt, Age, Glasgow Coma Scale.
[a]Analyzed using chi-square test.
*Statistically significant at $P<0.05$.

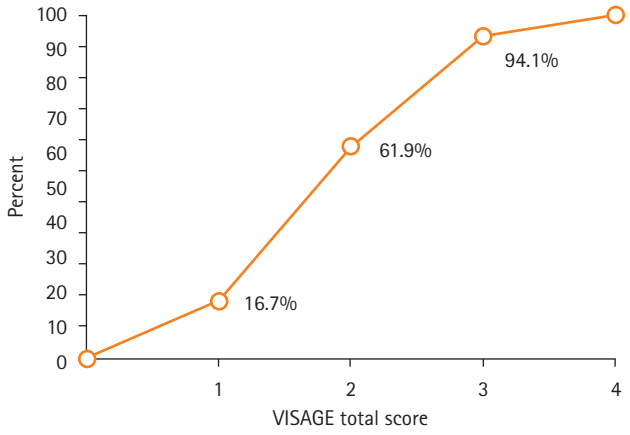

Fig. 4. Rate of extubation success according to the number of Visual pursuit, Swallowing attempt, Age, Glasgow Coma Scale (VISAGE) total score.

airways in these patients. Steidl et al. [10] reported that 47% of subjects underwent tracheostomy after mechanical ventilation because of loss of protective reflexes, which predominantly occurs in severe brain injury, including hemorrhagic stroke.

Despite the important role of mechanical ventilation in regard to neurocritical care, shortening the duration of intubation reduces the risk of ventilator-related complications, morbidity, and mortality, thereby lowering hospital care costs. As soon as the precipitating factors leading to respiratory failure are corrected, weaning from mechanical ventilation can be initiated. Weaning is a gradual transition from mechanical ventilation to extubation. Some parameters must be considered when determining the time to extubation in patients in intensive care, particularly those in neurocritical care. The Rapid Shallow Breathing Index is commonly used before extubation to predict failure or success. This score is used globally to allow patients to proceed to SBT [13,14]. Subsequently, various parameters using certain scores were used to predict extubation failure or extubation success in intensive care patients, where failure to control secretions was the most common factor contributing to extubation failure. The patients with numerous endobronchial secretions are to 3–8 times more likely to have extubation failure than those with no or mild secretions. In addition, cough strength and mental status affect the success of extubations [15-18].

Along with the development of interest in regard to neurocritical care, other parameters for predicting extubation outcomes after mechanical ventilation have also been developed, such as the ExPres score [19,20]. The combination of the Rapid Shallow Breathing Index, muscle strength, duration of mechanical ventilation, and laboratory results, including hematocrit, are the components of ExPres. This score is simple and easy-to-implement [20]. Nayak et al. [21] showed that the ExPreS score was independently associated with extubation outcomes, using a cutoff value of 59 points. Using the same cutoff value, Baptistella et al. [20] showed a sensitivity of 88.9% and specificity of 75.2%. The current study has revealed similar values of sensitivity of 89.5%, specificity of 88.9%, and accuracy of 89.3%. On the other hand, a higher cutoff points of ≥69 showed lower sensitivity (70.9%), specificity (69.4%), and accuracy (70.3%) [21]. Furthermore, higher cutoff values also contributed to lower AUC values (0.730) compared to the lower cutoff of 59 points (0.875) [20,21]. The AUC value of ExPreS in our study was 0.945, and the lower score found in the study was due to previous studies showing a greater incidence of VAP [20,21]. Baptistella et al. [22] in their study also conducted external validation in a randomized clinical trial in order to compare the predictive capacity of ExPreS versus the standard protocol on extubation outcomes. They found that the extubation failure rate was 12.9% in the standard protocol, when compared with 7.8% in the ExPreS group, showing that the use of ExPreS can decrease the extubation failure rate [22].

In addition to the ExPres score, Asehnoune et al. [8] recommended a series of simple motor examinations (such as opening and closing the eyes, visual pursuit examination, and swallowing attempts), named VISAGE score, which can also facilitate patient assessment. The parameters of the VISAGE score showed great potential as predictors of extubation outcomes in severe brain injury [8,23,24]. VISAGE combines clinical variables expected to improve the effectiveness of mechanical ventilator use in neurocritical patients. According to a previous study conducted by a VISAGE value of more than two points shows a higher success rate than a lower value (<2) [8]. This also supports the importance of assessing neurological and airway functions, along with other ventilator parameters [24]. A previous study reported an AUC value of the VISAGE score of 0.75, which is similar to the findings of the current study, with an AUC value of 0.876. These results indicate that the VISAGE score accurately predicts extubation success [8,25].

This study has found that a VISAGE score of >2 points could

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predict extubation success with a sensitivity value of 63.2%, specificity of 94.4%, positive predictive value of 96.0%, negative predictive value of 54.8%, and accuracy of diagnostic of 73.2% in neurocritical patients. Using the same cutoff point, Asehnoune et al. [8] also showed similar result of sensitivity values 62%, specificity of 79%, positive predictive value of 90%, and negative predictive value of 39% for the VISAGE score. By increasing the VISAGE score cutoff point to > 3, Mona [26] in their study obtained different values of sensitivity by 71.3%, specificity of 47.1%, positive predictive value of 88.9%, and negative predictive value of 21.6% with an AUC value of 0.635. Higher VISAGE scores were associated with fewer complications, shorter ICU and inpatient stays, and good GCS at discharge. Muzette et al. [24] also showed that the simple VISAGE score method significantly predicted the time for extubation in acute brain injury, with a success rate of 75.42%.

The strength of this study is that it provides data on the combination of respiratory and non-respiratory components that could aid in determining the time for extubation in neurocritical patients, the data of which are limited to date. There are also limitations to this study: the absence of adjustment for confounding factors (e.g., sedation level and comorbidities), the relatively small sample size (which limits generalizability), and the single-center design (which may reduce external validity). Therefore, multicenter validations, prospective trials comparing scoring systems, and integration with other clinical parameters are recommended for future research.

Owing to their high sensitivity, specificity, and diagnostic accuracy, ExPreS and VISAGE scores can be used as reliable parameters to help determine the timing of successful extubation in neurocritical patients on mechanical ventilation.

ARTICLE INFORMATION

Ethics statement

This study was approved by the Ethical Committee of Universitas Sumatera Utara, Medan, Indonesia (No. 642/KEPK/USU/2024). Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper.

Conflict of interest

No potential conflict of interest relevant to this article.

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Conceptualization: AK. Methodology: AK. Software: TA. Validation: TA. Formal analysis: TG. Investigation: HSH. Resources: TG. Data curation: HSH. Visualization: TG. Supervision: AK. Project administration: AK. Funding acquisition: AK. Writing – original draft: AK. Writing – review & editing: HSH. All authors read and agreed to the published version of the manuscript.

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